

DOCKET FILE COPY ORIGINAL

RECEIVED

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

APR 25 1994

FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

In the Matter of

Guidelines for Evaluating the
Environmental Effects of
Radiofrequency Radiation

)
)
)
)
)
ET Docket No. 93-62

Motorola is pleased to submit these Reply Comments in response to the Commission's proposal in the above-captioned proceeding.

Respectfully Submitted,



Donald L. Walker
Director, Technical Programs
Motorola Inc.
Government Relations Office
1350 I Street, N.W., Suite 400
Washington, DC 20005
(202) 371-6947

April 25, 1994

No. of Copies rec'd
List ABCDE

047

INTRODUCTION

In its Comments in this proceeding, Motorola addressed many of the important matters put forth by the Commission in the Notice. We specifically provided: detailed information relative to the SAR measurement procedures and levels associated with portable cellular telephones; and information relative to spacing requirements from typical base station antenna site installations in order to adhere to the ANSI Standard.

Others in their Comments also addressed the matter of antenna site installations. In particular, Paging Network Inc. included measured data in its Engineering Report indicating power density levels slightly above the ANSI Standard in one roof corner of one building. Also Doty-Moore Tower Services, Inc. in its Comments provided measured data for two sites which indicated that the levels prescribed by the ANSI Standard were exceeded.

In these Reply Comments, Motorola would like to report on its measurements at a variety of Land Mobile sites, involving both Cellular and Private Land Mobile operations. These measurements are part of an ongoing program that we have had in place to determine radiofrequency levels at these sites, and to take appropriate action in those few cases where it is warranted.

SUMMARY OF BASE STATION ANTENNA SITE MEASUREMENT DATA

Land mobile base station sites involving trunked, conventional, paging, and cellular operations produce a level of exposure to people that is normally well below the ANSI C95.1-1992 standard. The factors that contribute to this fact are detailed in APPENDICES A and B of these Reply Comments.

Two classes of people could conceivably be exposed to radiofrequency energy from various Land Mobile radio sites--those in the general population and those who work

around the radio equipment. With regard to the former, there are two examples of radio sites which should be analyzed to determine the level of radiofrequency energy that might be experienced by people in the general population—the relatively new E-SMR (Extended SMR) service and the Cellular service. These services use directional antennas which have a relatively large vertical beamwidth, and normally employ relatively low antenna heights. Thus, there is at least a theoretical opportunity for a variety of people to be exposed to the associated radiofrequency energy.

Computations in APPENDIX A show that the level to which the general population might be exposed is several thousand times lower than the ANSI C95.1-1992 standard. Moreover, measurements on three sites in the Chicago area, contained in this Appendix, indicates that the level is below the minimum sensitivity of the instrument used, which is some 20 times below the standard for the uncontrolled environment. This information, taken together, leads to the conclusion that the exposure levels of the general population from radiofrequency energy associated with these types of radio sites is indeed very low.

In contrast to the types of radio sites just discussed, more traditional Private Land Mobile sites are chosen to cover a wide area for dispatch applications to many users, and thus employ relatively high antenna heights, often on building tops. This characteristic makes them inaccessible to the general population. Furthermore, workers on the equipment that is located at these sites are normally instructed to disable any transmitter before doing work that might expose them to fields that exceed the ANSI standard. Importantly, this instruction also applies to transmitters that are attached to antennas that are near them when they are working on another system nearby.

On most of the just-described sites, the levels that are experienced by workers do not exceed the controlled environment Maximum Permitted Exposure (MPE), even on a continuous basis. It is possible, however, that under unique circumstances, the fields on such a site might exceed this MPE if an individual stays in one spot close to the

antennas for six minutes or more. Any such locations are quantified by measurements, and signs are used, as described in ANSI C95.2-1982; limited access is imposed to assure that anyone entering the site is aware of how to maintain exposure below the MPE. In a sample of 9 measured sites presented in APPENDIX B, only one site required these measures.

In general, the maximum exposure to both workers and the general population from the base station sites for all forms of Land Mobile radios has been below the ANSI C95.1-1992 standard, and the average exposure has been several thousand times below the standard. Ongoing measurement programs will assure that the level of exposure will continue to be below the standard as transmitters are added to the sites and new sites are added to those already in existence.

APPENDIX A

Abstract:

Measurements have been made at three Cellular sites in the Chicago area to determine the level of RF to which the general population might be exposed. The level was below 0.0265 mW/sq. cm, the minimum sensitivity of the Holaday Industries probe that was used to make the measurement. This is consistent with computations of the level expected from typical installations. Thus, the exposure to the public to RF when they are near these sites is well below the MPE for uncontrolled exposure in ANSI C95.1-1992

Introduction:

The popularity of Cellular has lead to rapid growth of the number of cellular sites in the U.S. These sites are typically located on relatively low towers and with directional antennas which have a relatively large vertical beam width near areas where the mobile population travels. Thus, many people may be exposed to the RF from the cellular base sites.

Computations of the level to which the general population might be exposed depend on the distance from the antenna to the individual member of the general public, the gain of the antenna in the direction of the individual, the power being transmitted by the antenna, and the amount of time the individual spends in the area. Typical values will be used to quantify the levels that might be expected, and measurements will be presented that confirm these levels.

Computations:

Typical antennas used in this service are panel designs with about 9 dBd (11.15 dBi) of gain that have vertical half power beam widths of about 20 degrees*. The Effective Radiated Power (ERP) radiated from the antennas is 100 watts per channel, and there are frequently 16 channels** in each direction for a total ERP of 1600 Watts. Tower heights of 75 feet are the norm, and the aperture of the panel antennas is about 3 feet, so the far field criteria*** is met even on the ground beneath the antennas.

* There are higher gain antennas such as the 16 ± 1 dBd PD1132R of Celwave, with a vertical half power beam width of only 8 degrees, though this antenna is not used on the sites reported on the following pages. More will be said about the use of this antenna later.

** There can be up to 96 transmitters in some unique cases. More will be said about the impact of this later.

*** The far field criteria is that the distance, d , to the antenna is greater than $2D^2/L$ where D is the maximum length of the antenna and L is the wavelength. For this antenna at the cellular transmit frequency of 875 MHz, the far field is met at a distance of about 16 feet.

The power density in the far field of an antenna is found by dividing the power radiated in the direction of interest by the area of a sphere of radius equal to that distance. The distance to a person located at the half power point on the antenna (8.15 dBi of gain) at a point 5 feet above the ground is 403 feet from the antenna. Assuming that all 16 transmitters are on, the computed power density for these 16 channels at this distance is 0.00009 mW/sq. cm. Using the vertical pattern gain of a Celwave PD10176 the power density as a function of distance from the base of the antenna was computed and is shown in Figure 1.

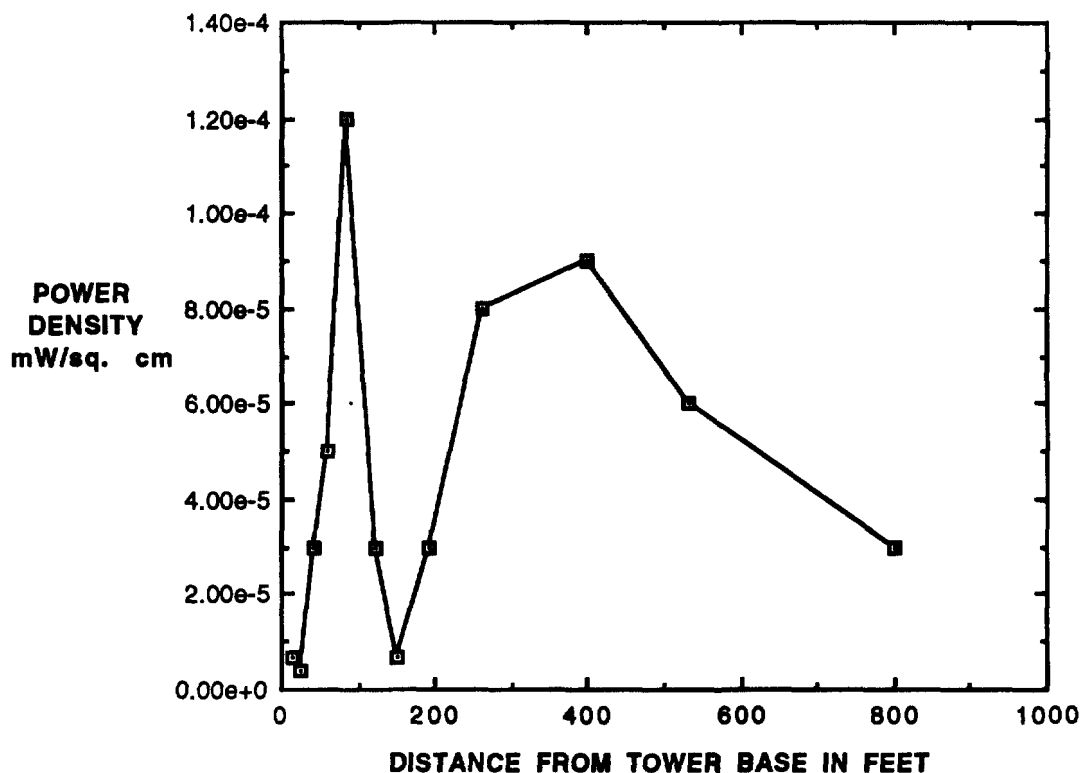


Figure 1 Computed power density vs. distance from a panel antenna radiating 1600 Watts ERP.

The maximum power density occurs on the side lobe of the antenna at a distance of about 80 feet from the base of the tower. The ANSI MPE for the uncontrolled environment at the cellular frequency of 870 MHz is 0.58 mW/sq. cm, so this maximum of .00012 mW/sq. cm is more than 4800 times lower than the MPE. It is possible to have reflections from the ground or a wall that will approximately double the electric field or quadruple the power density. Even under these conditions, the predicted exposure is over 1000 times lower than the MPE*.

* The worst case gain was previously given as 17 dBd, and the sidelobes for this antenna are at about the same relative level as those used in the example. So,

Measurements:

Three cellular sites in the Chicago area were selected to measure the level of RF that is present. They are located at Cook Co. IL, Route 14 & 68, Lake Co. IL, Route 14 & Peper Rd., and Schaumburg IL, N.W. Toll Rd. & Wiley Rd. The base equipment is housed within a small building at the base of the tower at each site and the tower and building are enclosed in a chain link fence limiting access. The number of transmitters at these sites was not determined, but these are established sites in major growth areas, having been there for several years, and it is believed that they are typical of most sites in the area. Directional cellular antennas are mounted on each tower as are other antennas to provide sectorized cellular coverage and other communications links.

The measurements at these locations were made with a Holiday Industries model HI3002 probe which had been recently calibrated at 835 MHz. The calibration demonstrated that the probe measured within about 0.4 dB of the electric field present with an isotropicity of $\pm 1/4$ dB. The specification for the probe at this frequency is ± 2 dB and ± 0.5 dB for those two parameters respectively, so the probe was well within the stated specifications. The minimum scale reading on the probe is 0.0265 mW/sq. cm. Therefore, if the computed levels are present, there should be no meter indication during the measurements.

The measurement procedure consisted of walking in a grid over the area within about 500 feet of the tower base, where access to the public was permitted, while moving the probe up and down from about 20 cm from the earth to a point about 2 m above the earth. The measurements were made at busy hours during the day to maximize the number of transmitters on while the measurement was made.

The results were the same at each site, and were as expected. It was not possible to move the needle on the meter with the RF fields from the cellular sites. The frequencies of interest are in the cellular band, and the ANSI standard MPE for the uncontrolled environment at a cellular frequency of 870 MHz is 0.58 mW/sq. cm. Thus, the measurements demonstrate that the exposure of the public near these sites is well below the standard.

the fields produced can be about 8 dB higher than those computed in this example. Also, the potential number of transmitters can be 96 which can cause a 7.8 dB increase in the fields. These sum to a total of 15.8 dB, or a power density exposure that can be a factor of 37.8 times higher than the example. Even if this worst case is applied to the computation, the level of the potential exposure is still better than 30 times lower than the MPE for the uncontrolled environment of the ANSI standard.

Conclusion:

Measurements and computations of the RF exposure of individuals in the area of three typical cellular sites in the Chicago area show that the fields are below the MPE for the uncontrolled environment of ANSI C95.1-1992. However, these fields are still hundreds of times below the MPE of the ANSI standard.

APPENDIX B

Abstract:

Land mobile sites are well removed from the general public so that the sites meet the criteria of a controlled environment in ANSI C95.1-1992. Computations, measurements, and access control are used at these sites to keep the exposure of individuals to electromagnetic fields below the level of the MPE for the controlled environment in that standard.

Introduction:

Traditional land mobile sites are chosen for their height so that high power transmitters can cover a wide area for dispatch applications to many users. This characteristic makes them relatively inaccessible to the general population. Thus, these sites are considered a "controlled environment" for the purposes of the application of the MPE in the ANSI C95.1-1992 standard.

It is possible that, under unique circumstances, the fields at such a site might exceed the controlled environment MPE should an individual stay in one spot for more than 6 minutes. In such cases, signs are used, as described in ANSI C95.2-1982, and limited access is imposed to assure that anyone entering the site knows how to maintain their exposure below the MPE. This APPENDIX will describe the methods used to assure that the standard is met in all cases. This includes an ongoing measurement program to assure that the sites continue to meet the standard as changes are made over time.

The new E-SMR (Extended SMR) service uses relatively low sites as does the Cellular service, so that the exposure to the nearby general population is of importance. The exact parameters are different, but the general trend is the same. This case has been handled in APPENDIX A for typical Cellular installations, and the reader is referred there for further details.

Computations:

Before entering a site to make measurements of the fields present, the level of exposure is evaluated by making computations of the fields that are expected. Two models are used in the computation of the fields from a single antenna, the spherical model and the cylindrical model. The spherical model, applicable to all antennas uses the well known free space propagation that is applicable in the far field of the antenna. The cylindrical model, applicable to collinear arrays of elements, constrains the radiation to the surface of a right circular cylinder with the array at its center. These models have been placed on a spread sheet, and a sample is shown in TABLE 1 for a typical 10 foot aperture 850 MHz omnidirectional antenna with 50 watts into the antenna. At close spacings, in the near field of the antenna, the cylindrical results should be used; when the far field criteria is met, the spherical results are applicable.

TABLE 1
Spread Sheet Computation of Fields

Aperture length, ft =	10.00	milliwatts =	50000
Input Power W =	50.00	Power Gain=	13.0 isotropic
Antenna Gain, dBd =	9.00	EIRP =	651000. mW
Distance to Start, ft =	0.20		
Step Dist. in ft =	0.05		

MODEL = SPHERICAL				CYLINDRICAL			
Distance, ft	mW/cm2	V/m	A/m	Distance, cm	mW/cm2	V/m	A/m
0.20	1395	2293	0.608	6.10	4.28	127.0	0.033
0.25	892	1834	0.486	7.62	3.42	113.6	0.030
0.30	620	1529	0.405	9.14	2.85	103.7	0.027
0.35	455	1310	0.347	10.67	2.44	96.0	0.025
0.40	348	1146	0.304	12.19	2.14	89.8	0.023
0.45	275	1019	0.270	13.72	1.90	84.7	0.022
0.50	223	917	0.243	15.24	1.71	80.3	0.021
0.55	184	834	0.221	16.76	1.55	76.6	0.020
0.60	155	764	0.202	18.29	1.42	73.3	0.019
0.65	132	705	0.187	19.81	1.31	70.4	0.018
0.70	113	655	0.173	21.34	1.22	67.9	0.018
0.75	99.2	611	0.162	22.86	1.14	65.6	0.017
0.80	87.2	573	0.152	24.38	1.07	63.5	0.016
0.85	77.2	539	0.143	25.91	1.00	61.6	0.016
0.90	68.9	509	0.135	27.43	0.95	59.9	0.015
0.95	61.8	482	0.128	28.96	0.90	58.3	0.015
1.00	55.8	458	0.121	30.48	0.85	56.8	0.015

The MPE for the controlled environment at 850 MHz is 2.8 mW/sq. cm, and the cylindrical model which applies in the near field shows that the MPE is met at and beyond 0.3 feet (9.2 cm) from the radiator. The near field cylindrical model is independent of frequency, so this spacing applies for all land mobile frequencies at the same power input to the antenna. At a power into the same antenna of 500 Watts (the maximum power rating) the spacing required to meet the MPE is 3.0 feet (92 cm). A general criterion that is used for land mobile antennas of this length is that the MPE is met if one stays an arm's length away from the antenna when broadside to the antenna. This provides a guideline for going on the site to make measurements while assuring that the MPE is met.

Measurements:

On sites with only one, or a few widely spaced antennas, it is unnecessary to constantly re-measure the fields. The computations and measurements that have been made agree quite well, and the spacings to the antennas required to meet the MPE are very small. However, on medium to large sites (those with many antennas) the sum of the fields from the antennas should be measured to assure that the MPE is met.

A wide band instrument that is used to simultaneously measure all of the frequencies that are present on a site is the Holaday Industries 3002 broad band meter that includes both E and H field probes. A recorder is included that provides the time and instantaneous values as well as averages over time and a graphical indication of the instantaneous value. The average is taken over time, and by moving the probe in a vertical plane from 20 cm from the floor to 2 meters high, the average over the vertical cross section of the human body is easily taken. As indicated in ANSI C95.1-1992, the spacing to any object was maintained at 20 cm or greater. In general, the procedures described in ANSI C95.3-1992 were followed as the measurements were made.

TABLE 2 shows measurements which have been made within the past year that are typical of the maxima that have been detected on land mobile sites. In general, the average level measured at most locations is well below the MPE. The equivalent power density in the table is the maximum of the averages from 20 cm from the floor to a height of 2 meters that was found at the site where personnel from the land mobile industry have access as they go about their normal activities. This is also the worst case possible in that it is assumed that an individual will be positioned at this location for 6 minutes or longer.

The frequency indicated is not necessarily the only frequency on the site, however it is the one that is present at the location where the indicated power level is present. NA in this column indicates that no one frequency was dominant at that measurement location. Therefore, it is not applicable to identify a single frequency.

The MPE is met, under the assumed conditions, at all locations on these sites except at One Biscayne Tower in Miami, Florida where there is a ladder from one level of the roof to another that approaches within 2 feet of an 850 MHz antenna. Individuals are instructed to not spend more than 2 minutes on this ladder as they climb from one level to the other, and a sign as described in ANSI C95.2-1982 is used to warn people that the area is an RF energy controlled area. The sign also gives a phone number to be used to contact a knowledgeable individual for further information.

TABLE 2
Measured Levels at a Sample of Land Mobile Sites
Where Land Mobile Personnel Have Access

LOCATION	FREQUENCY, MHz	EQUIVALENT POWER DENSITY, mW/cm ²
Sears Tower, Chicago, IL	NA	0.8
Motorola Sector Hdqrs, Schaumburg, IL	NA	0.2
Barnett Bank, Tampa FL	NA	0.9
One Biscayne Tower, Miami, FL	850	3.2*
Tucson Mountain, Tucson, Az	NA	0.2
Mount Wilson, Los Angeles, CA	NA	0.9
Mount San Miguel, San Diego, CA	NA	0.2
Prudential Center, Boston, MA	900	2.6
Walker Tower, Waltham, MA	930	2.8

* Individuals on the site are instructed to spend less than 2 minutes in this location to assure that the 2.8 mW/sq. cm MPE is met.

Conclusion:

Measurements have been presented to show the maximum levels that are present at sites where land mobile personnel have access. In general, the fields are well below the MPE in ANSI C95.1-1992, so no special control is needed. But for unique areas of high RF energy, controlled access is used to limit exposure to the MPE.